The growth of depth-graded WSi_2/Si multilayer linear zone plates*

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Abstract

Fresnel zone plates, consisting of alternating transparent and opaque rings designed according to Fresnel phase conditions, are widely used to focus x-rays. Zone plates are commonly made using lithographic techniques and have achieved high spatial resolution on the order of 20 nm in the soft x-ray range. For hard x-rays, to achieve an optimum efficiency, the thickness of the zone plate needs to be several microns. The required high aspect ratio is difficult for lithography and imposes a limit to the focus spot size. Techniques have been developed using sectioned multilayer-coated wires to obtain a high aspect ratio, with concentric multilayers as the zone-plate rings. We have recently explored a linear zone-plate concept, by first growing a depth-graded multilayer on a flat substrate and then sectioning the multilayer and assembling several sections to focus the x-rays. The structure of the multilayer is calculated according to the desired focus parameters with corresponding Fresnel phase conditions. We have grown a depth-graded WSi_2/Si multilayer on a Si substrate using dc magnetron sputtering to test the linear zone-plate idea. The multilayer has a total of 469 alternating layers with thickness gradually increasing from ~15 nm to ~60 nm. It has a total coating thickness of ~11.27 μm and took ~45 h to coat. The sample has been sectioned and polished and studied using a scanning electron microscope and synchrotron radiation x-rays. The challenges and solutions for the growth of this kind of depth-graded multilayer will be discussed.

* This work is supported by the U. S. Department of Energy, under Contract No. W-31-109-ENG-38.